1013

INSTRUCTIONS AND APPLICATIONS

Beat Frequency Oscillator Type 1013

A Beat Frequency Oscillator covering the range 200 to 200000 Hz. The instrument is designed to meet the numerous requirements of a signal source for audio and supersonic frequency work. It is excellently suited both for electrical and electro-acoustical measurements, as well as for acoustic and supersonic research.

- Accelerometers
- Acoustic Standing Wave Apparatus
- Artificial Ears
- Artificial Voices
- Audio Frequency Response Tracers
- Audio Frequency Spectrometers
- Audio Frequency Vacuum-Tube Voltmeters
- Automatic A. F.Response and Spectrum Recorders
- Automatic Vibration-Exciter Control Generators
- Band-Pass Filter Sets
- Beat Frequency Oscillators
- Complex Modulus Apparatus
- Condenser Microphones
- Deviation Bridges
- Distortion Measuring Bridges
- Frequency Analyzers
- Frequency Measuring Bridges
- Hearing Aid Test Apparatus
- Heterodyne Voltmeters
- Level Recorders
- Megohmmeters
- Microphone Accessories
- Microphone Amplifiers
- Microphone Calibration Apparatus
- Mobile Laboratories
- Noise Generators
- Noise Limit Indicators
- Pistonphones
- Polar Diagram Recorders
- Preamplifiers
- Precision Sound Level Meters
- Recording Paper
- Strain Gage Apparatus and Accessories
- Surface Roughness Meters
- Variable Frequency Rejection Filters
- VHF-Converters
- Vibration Pick-ups
- Vibration Pick-up Preamplifiers
- Wide Range Vacuum Tube Voltmeters

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Beat Frequency Oscillator

Type 1013

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Description.

General.

The Beat Frequency Oscillator Type 1013 is designed for measurements in the frequency range 200—200ooo Hz and consists of an oscillator, mixer, and an amplifier section. It works on the heterodyne principle using two high-frequency oscillators, one of which operates on a fixed frequency, while the frequency of the other can be varied by means of a variable capacitor. The required signal frequency is obtained as the difference between the two high frequencies and can be read off a large illuminated scale, the pointer of which is connected to the variable capacitor. The scale is logarithmic and graduated from 200 to 200ooo Hz, and in addition an INCREMENTAL SCALE is provided, allowing exact frequency selection in the range — 500 to + 500 Hz for any setting on the main scale.

The frequency adjustment is carried out by obtaining a beat between the fourth harmonic of the line voltage and the oscillator voltage, occurring when the oscillator is tuned to this frequency and the push-button marked LINE FREQUENCY BEAT FOURTH HARMONIC on the front panel is pressed.

The variable capacitor has two control knobs, one of which is directly connected to the capacitor spindle and is used for quick setting of the approximate frequency. The other will, when pressed, rotate the spindle with a ratio of 1 to 5 and allow fine tuning to the desired frequency.

A worm gear permits the capacitor to be tuned automatically, for example by the aid of the motor in the Level Recorder Type 2305. The mechanical connection to the Level Recorder is effected by means of a flexible shaft which can be screwed onto the bushing on the side of the Oscillator cabinet. The worm gear can be engaged and released with the aid of a built-in electromagnetic clutch, operated from a switch on the front panel marked AUTOMATIC SCANNING or by a remote control arrangement. The electromagnetic clutch is a friction device, so that manual tuning of the variable capacitor is possible even when the clutch is engaged.

The Beat Frequency Oscillator is provided with frequency modulation. A reactance tube, controlled by saw-tooth oscillations from a built-in oscillator, may be switched into the circuit of the fixed oscillator. The frequency of the saw-tooth oscillator is controlled by the switch marked MODULATION FREQUENCY, and the amplitude of the saw-tooth oscillations, which controls the frequency deviation, is regulated by FREQUENCY DEVIATION.

Provision is also made for external modulation whereby very wide limits of frequency modulation can be obtained.

By means of a level regulator circuit (COMPRESSOR) which can be controlled from an external voltage, it is possible to keep the voltage current, or sound pressure constant during measurements, when the oscillator is being used as a power source, (LOAD).

Oscillator and Mixer Section.

Fig. 1.1 shows a block diagram of the complete Oscillator. The diagram is divided by means of a dotted line showing the oscillator and mixer section, and the amplifier section respectively.

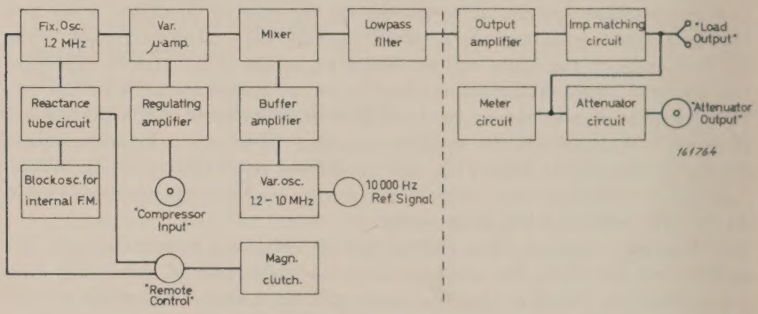


Fig. 1.1. Block diagram of the BFO 1013.

The fixed oscillator is tuned to 1.2 MHz and can be frequency modulated by means of an arrangement also shown in Fig. 1.1. The reactance tube circuit acts as a variable inductance and the modulation swing can be continuously varied from 0 to ± 2000 Hz by means of a potentiometer on the front panel of the apparatus, marked FREQUENCY DEVIATION.

By means of the switch marked MODULATION FREQUENCY the frequency of the built-in saw-tooth oscillator may be chosen. Frequencies of 2—4—8—16—32 and 64 Hz are available. The oscillator is a blocking type, tuned to approximately 7 MHz, and the frequency of the saw-tooth oscillations is selected by the changing of the grid resistor.

Provision is made for external modulation, for which the external generator should be connected to two terminals of the jack on the front plate marked REMOTE CONTROL. For external modulation a voltage of approximately 5 volts is necessary when a modulation swing of ± 2000 Hz is required. The impedance of the external generator must be low (approximately 1 kΩ). When external modulation is employed the switch marked MODULATION FREQUENCY must not be in position "Mod. Off" as in this position of the switch the reactance tube is cut off.

A variable capacitor of 60 pF, inserted in the tuned circuit of the fixed oscillator, and operated by the knob marked FREQUENCY INCREMENT,

permits exact frequency selection in the range ± 500 Hz in relation to the setting on the main scale.
By means of a noiseless switch on the front panel, marked OSCILLATOR STOP, the voltage on the anode of the 1.2 MHz oscillator can be disconnected. This arrangement is specially provided for reverberation measurements. The identical operation can be obtained by remote control ,this can be seen from the circuit diagram of the Oscillator.

The output voltage from the fixed oscillator is fed to the grid circuit of a pentode, the grid bias of which is controlled by a regulating amplifier. To obtain a high degree of regulation, the working-point of the pentode is chosen on the non-linear portion of the I_a-E_g characteristic, near cut-off. The purpose

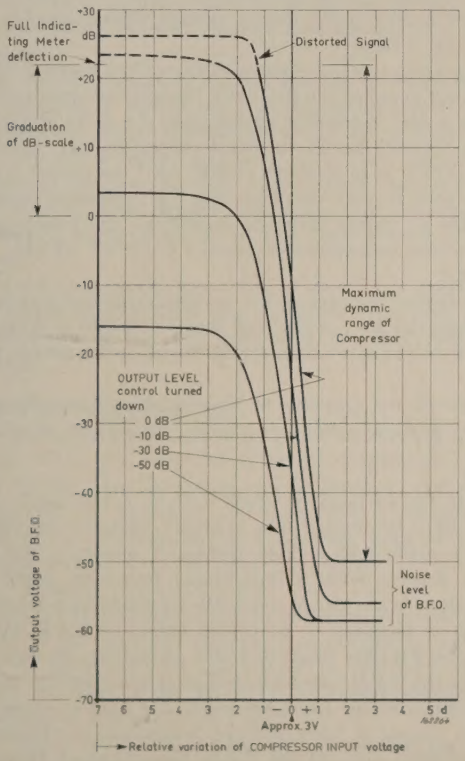


Fig. 1.2. Regulation characteristics for different positions of the potentiometer marked OUTPUT LEVEL.

of this circuit is to control automatically the output of the Beat Frequency Oscillator by applying an external voltage. The external control voltage should be fed into the screened jack marked COMPRESSOR INPUT on the front panel of the Oscillator.
A variable potentiometer, marked COMPRESSOR VOLTAGE is inserted in the input circuit of the regulating amplifier and can be used as level control for the output from the Oscillator, when automatic regulation is employed. The regulating amplifier has a linear frequency characteristic from 200 to 200ooo Hz and should have an input signal of approximately 3 volts on the grid of the amplifier tube for full regulation. The input impedance, measured across the terminals of the jack marked COMPRESSOR INPUT is approximately 10 kohms, and the obtainable range of regulation is at least 45 dB.
The amplified control voltage is rectified in a full-wave double-diode rectifier, designed to give a DC output voltage proportional to the average value of the control voltage.
The speed of regulation can be varied with the switch marked COMPRESSOR SPEED on the front panel of the Oscillator. Regulation speeds of 30 — 100 — 300 or 1ooo dB/sec may be chosen by changing the value of the capacitor in the R-C filtering network for the rectified control voltage. When the switch COMPRESSOR SPEED is in position COMP. OFF the output from the rectifier is short-circuited thereby disconnecting the automatic regulation.
It is also possible to obtain different regulation characteristics dependent on the position of the potentiometer marked OUTPUT LEVEL. This can be seen from Fig. 1.2.
To obtain good regulation even when maximum output power is required from the Oscillator, the level of the high frequency voltage from the 1.2 MHz fixed Oscillator is raised approximately 10 dB when the automatic regulation is switched in.
The anode-circuit of the pentode in the variable μ-amplifier is tuned to 1.2 MHz, thereby forming a band-pass filter, the output of which is fed to the mixer.

The frequency of the variable oscillator can be continuously altered from 1.2 MHz to 1.0 MHz by means of a specially designed variable capacitor. This capacitor is made with a high degree of accuracy and a maximum deviation of o.7 degrees from a logarithmic frequency curve is obtained. The Frequency Main Scale can be remotely scanned via a mechanical drive. The arrangement is intended to be driven from the B & K Level Recorder Type 2305 via the Flexible Shaft UB 0041 (1 meter). In this manner the frequency scan of the B.F.O. can be driven in synchronism with the pre-print of the recording paper of the Level Recorder. The built-in worm gear, having a ratio of 50 :1, causes a scale pointer movement corresponding to one octave, when the input drive of the B.F.O. turns through three revolutions. The worm gear can be set and released by a magnetic slutch which is operated from a switch (AUTOMATIC SCANNING) on the front panel of the

Oscillator, or it can also be operated from an external switch or relay. In the latter case connection must be made to the appropriate terminals of the jack marked REMOTE CONTROL on the front panel, and the control switch AUT. SCANNING for the magnetic clutch must be in position "Off".
By means of a pushbutton marked 10ooo Hz REF. SIGNAL, an extra capacitor is introduced in the tuning circuit of the variable oscillator.
There vill be exactly 10ooo Hz at the output socket when the scale pointer is set to 10ooo Hz REF. SIGNAL and the pushbutton 10ooo REF. SIGNAL is depressed.
The reason for setting the scale pointer at 10ooo Hz REF. SIGNAL is in order to be able to align the 1013 with the frequency calibrated paper, used on the Level Recorder Type 2305, as this paper is calibrated from 10 Hz. The distance between the calibration mark of 10 Hz and 20 Hz on the recording paper corresponds to the distance between 1ooo Hz REF. SIGNAL and 200 Hz on the oscillator.
By depressing the pushbutton it is now possible to check that the level of the middle frequencies is within the divisions of the paper.
The voltage developed across the grid circuit of the variable oscillator is fed to the mixer tube via a buffer amplifier stage. This stage, which prevents undesired coupling between the fixed and variable oscillator, also increases the signal level to a value required for correct functioning of the mixer. The mixer tube is a triode giving a low hum level in spite of the AC heating of the filament.
A low-pass filter with a cut-off frequency of 500 kHz is inserted in the anode circuit of the mixer tube, passing only the lower frequency obtained by the frequency conversion to the grid circuit of the first tube in the output amplifier section.

Partial Blocking of Frequency Range.
As previously mentioned, the frequency scale is logarithmic and calibrated 200—20ooo Hz. When the capacitor is set to frequencies above 20ooo Hz or below 200 Hz the fixed Oscillator can be blocked, and consequently no output voltage will be obtained. For automatic recording of frequency characteristics, i.e. when using the Level Recorder Type 2305, this is a great advantage as no unwanted curves will then appear on the corresponding section of the frequency calibrated paper.
The cut-off section can be made wider by adjusting the cam discs, connected to the rear end of the capacitor spindle. It is possible to cut down the frequency range to approximately one octave in any part of the range of 200—200ooo Hz. However, if the REMOTE CONTROL plug is removed there will be no blocking at any part of the scale.
In application where the B.F.O. is employed in conjunction with the B & K Level Recorder, and where automatic recording is required, the blocking arrangement can also be used for remote lifting of the Level Recorder's writing pen. This is a great asset in for example measurements where the

compressor circuit of the B.F.O. is used. In this instance the pen-lifting arrangement of the Level Recorder can be controlled from the frequency blocking circuit by making the appropriate connections to the REMOTE CONTROL jack of the B.F.O. In cases where the entire frequency range (200—200ooo Hz) of the B.F.O. is utilized, the normal frequency blocking, which functions outside the scale graduation, should be set out of operation. The writing pen of the Level Recorder can now be lifted from the paper outside the frequency range of interest and a proper working of the compressor also at the initial frequency (200 Hz) is ensured during the automatic scan. If the described methods is not utilized, the following would take place: No signal will be present in the range 200ooo Hz to 200 Hz (outside the scale graduation), i.e. the compressor of the B.F.O. will be in such a condition to give full output signal of the B.F.O. Consequently, when the scale pointer goes inside the scale graduation (200 Hz) full output level will be transmitted at 200 Hz, and after the chosen time delay (COMPRESSOR SPEED) the signal level will be compressed to the proper (preset) value. A deflection on the recording paper which is not a response of the measured object would thus be recorded.

Output Amplifier Section.

The voltage from the low-pass filter is fed to the control grid of the first tube in the two-stage output amplifier via a variable potentiometer. This potentiometer is operated by the knob marked OUTPUT LEVEL on the front panel of the Oscillator and is used for continuous adjustment of the output power. The gain of the amplifier is stabilized by negative voltage feedback. The anode circuit of the output tube is coupled to the impedance matching circuit.

Four different output impedances are available and can be chosen by the switch on the front panel marked MATCHING IMPEDANCE. The different positions of the switch are indicated by 6, 60, 600 and 6ooo ohms respectively and the output voltage is taken from the terminals marked LOAD. It should be noted that the output impedance of the Oscillator is only approximately 20 % of the indicated values, but with correct loading maximum power output is obtained with minimum harmonic distortion (Fig. 1.3). In addition, correct loading ensures the output voltage to be independent of the frequency to within $\pm$ 1 dB for frequencies between 200 and 200ooo Hz. A fifth position of the switch MATCHING IMPEDANCE is marked "Att." and connects the output transformer to an attenuator, variable in steps of 10 dB from 400 μvolts to 12.5 volts. The attenuator is operated by the switch marked ATTENUATOR on the front panel. In this position of the impedance switch the output circuit is connected to the screened jack on top of the front panel. The output impedance is constant and approximately 50 ohms. The accuracy of the attenuator is better than $\pm$ 2 %.

The voltage on the output terminals is indicated by a vacuum-tube voltmeter

which measures the average value of the output voltage. It is calibrated in RMS values for sinusoidal voltages.

The sensitivity of the voltmeter is automatically changed when the position of the switch marked MATCHING IMPEDANCE is altered. Full deflection of the meter is indicated on the switch. In addition to the volt calibration on the switch ATTENUATOR OUTPUT there is also a dB calibration ,and the calibration is, as mentioned above, given in dB re. 1 volt. An example will explain the use of the dB scale: If the OUTPUT LEVEL is adjusted in such a way, that 20 dB is read on the meter scale, and the switch ATTENUATOR OUTPUT is in the position — 30 dB then the signal level at the output socket will be 20 — 30 = — 10 dB re. 1 volt (0.316 V).

When the MATCHING IMPEDANCE switch is in position "Att." the output voltage available from the ATTENUATOR OUTPUT will depend on the position of the ATTENUATOR OUTPUT switch, in this case full deflection of the meter corresponds to the value indicated by the switch position.

The signal-to-noise ratio of the Oscillator is greater than 70 dB for maximum output voltage. By "noise" is here meant: The root mean square of internally induced noise, hum and spurious frequencies.

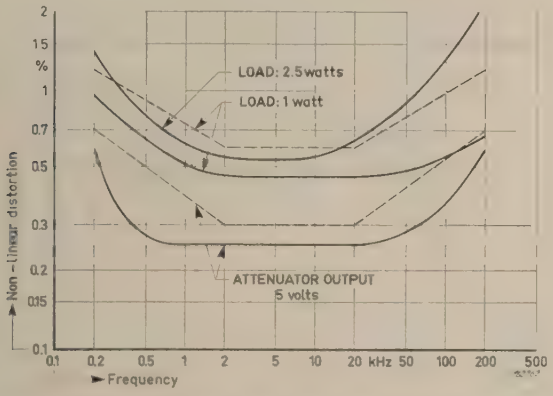


Fig. 1.3. Distortion curves for different loads. The curve marked »Att. 5 Volts" is obtained from measurements taken on the ATTENUATOR OUTPUT terminal, open circuited.

Power Supply.

The Oscillator can be operated from a 240, 220, 150, 127, 115 or 100 volts AC, 50—400 Hz power line, the power consumption being about 70 watts.

The proper voltage is selectable by a switch-fuse combination situated at the rear of the instrument. To select the voltage it is necessary to remove the fuse by turning the hexagonal disc head in the centre of the switch anticlock-

wise. Then with a coin turn the head of the voltage adjuster until the white mark is aligned with the required voltage. The fuse is then replaced.
It should be noted that if the apparatus is to be operated from a DC power line, or from an accumulator, a vibrator unit or a rotary converter is required.

2. Control Knobs, Terminals and Shafts

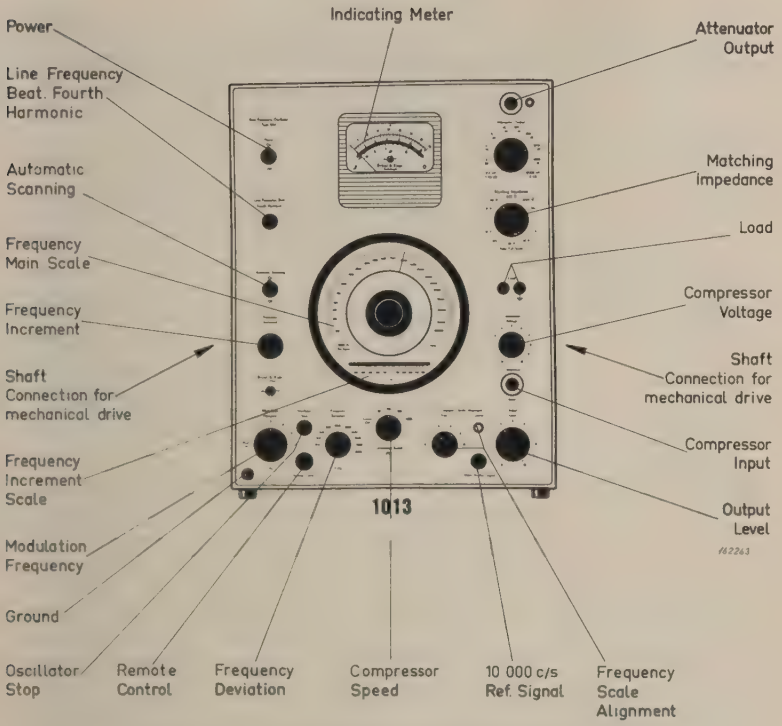


Fig. 2.1. Beat Frequency Oscillator Type 1013.

Power: When switched to "On" the meter scale and frequency scales will be illuminated.

LINE FREQUENCY BEAT FOURTH HARMONIC: Pushbutton, when pressed and held in, a beat between power supply frequency and output frequency of the B.F.O. can be observed on the in-

dicating meter. By this arrangement the output frequency can be brought to coincide with the calibration of the Frequency Main Scale.

AUTOMATIC SCANNING: This switch, when in the On" position, allows the variable capacitor of the B.F.O. to be connected to a worm drive which can be connected to, and driven from an external motor.

FREQUENCY MAIN SCALE: Logarithmic. Indicates the output frequency when the B.F.O. is frequency calibrated by the LINE FREQUENCY BEAT arrangement and Frequency Increment Scale is set to "0".

FREQUENCY INCREMENT: This makes available exact frequency selection in the range — 500 to + 500 Hz for the setting on the Frequency Main Scale. FREQUENCY INCREMENT setting is readable on the Frequency Increment Scale.

SHAFT CONNECTION for MECHANICAL DRIVE: Located on both sides of the instrument for the connection of an external mechanical driving source for automatic frequency sweep. The Shaft Connection fits the Flexible Shaft UB 0041 which forms the mechanical link between the B.F.O. and the Level Recorder Type 2305.

MODULATION FREQUENCY: Switch allows the frequency of a built-in blocking type oscillator which is used to frequency modulate the oscillator output signal to be set to 2—4—8—16—32 and 64 Hz.

OSCILLATOR STOP: This unit is specially installed for reverberation measurements and is a noiseless switch which disconnects the anode voltage of the fixed oscillator.

REMOTE CONTROL: Beneath the cap is provided six terminals for the connection of various external forms of remote control and external frequency modulation. Method of connection is fully explained under paragraph "Remote Control".

MODULATION DEVIATION: By utilizing a reactance-tube circuit as a variable inductance the fixed oscillator can be frequency modulated with a modulation swing of 0 to 2000 Hz by the setting of this potentiometer.

COMPRESSOR SPEED: This switch changes the time constant in the regulation circuit and allows regulation speeds of 30—100—300 or 1000 dB/sec to be obtained.

10000 Hz REF. SIGNAL: When the main scale is set on 10000 REF. SIGNAL and the pushbutton marked 10000 Hz REF. SIGNAL is pressed the frequency of the output signal will be exactly 10000 Hz.

FREQUENCY SCALE ALIGNMENT: "Fine", "Coarse". After the warming-up period these adjustment can be used to adjust the output frequency to be identical to that selected on the Main Scale. The screwdriver-adjusted "Coarse" allows greater variation than the "Fine" setting.

OUTPUT VOLTAGE: Potentiometer gives continuous adjustment of the output signal when the automatic (COMPRESSOR) is not in operation.

COMPRESSOR INPUT: This terminal is provided for the external connection of equipment which will supply the necessary signal for automatic output regulation of the BFO.

COMPRESSOR VOLTAGE: Variable potentiometer placed in the input circuit of the regulating amplifier of the BFO. When automatic regulation is employed this can be used for volume control of the output signal of the oscillator.

LOAD: Two output terminals for matching to an external load. The right-hand terminal is grounded.

MATCHING IMPEDANCE: Switch selects matching to four different load impedances of 6, 60, 600 and 6000 ohms respectively. A fifth position marked "Att." connects the oscillator output transformer to an attenuator.

ATTENUATOR: This switch allows the output to the terminal Attenuator Output to be attenuated in steps of 10 dB from 12.5 Volts to 400 μVolt.

GROUND: Terminal is placed at side of output terminal and gives an additional means of grounding if necessary.

3. Operation

General.

First ascertain that the Beat Frequency Oscillator is set to the appropriate power supply voltage by means of the selector at the rear of the instrument and that the Remote Control plug on the front panel is firmly home.

A. Frequency Calibration.

1. Snap the toggle switch marked POWER to "On" and allow two minutes to warm up.
2. Set MODULATION FREQUENCY and COMPRESSOR SPEED switches to their "Off" position.
3. Check that the frequency incremental scale is on zero. If not, set by FREQUENCY INCREMENT KNOB to this point.
4. Turn main scale pointer to frequency which is "4" times that of the line voltage (e.g. 200 for a 50 Hz mains). The fine adjustment knob of the main scale pointer is operated by pressing and turning.
5. Set suitable deflection on meter by turning knob marked OUTPUT VOLTAGE to higher than center scale reading.
6. Press LINE FREQUENCY BEAT button and hold to "in" position and at the same time rotate FREQUENCY SCALE ALIGNMENT "Fine" slowly, until a large fluctuation registers, slows up, and practically ceases on the meter dial. Two points may be found where this occurs, only one of which is correct and therefore a check as outlined in the following paragraph should be carried out, firstly releasing the LINE FREQUENCY BEAT button.
7. With the FREQUENCY INCREMENT knob, reduce total scale reading to 0 (i.e. mains scale reading + incremental scale reading = 0). If frequency calibration is correct meter needle will drop to zero indicating that the BFO is properly tuned. If not, readjust FREQUENCY SCALE ALIGNMENT to obtain zero meter deflection and repeat procedure from item 3 through 6.
9. Finally return FREQUENCY INCREMENT to zero and BFO is ready for use.

Note: If zero point cannot be found and is outside the range of the FREQUENCY SCALE ALIGNMENT "Fine" re-align the variable capacitor marked "Coarse" with a screwdriver to give a suitable setting which

should occur at some point between 3 and 5 on the FREQUENCY SCALE ALIGNMENT "Fine".

B. Operation Using the Output Terminals Marked "Load".

Apply the following procedure:—

1. Set-up and calibrate the oscillator as described in A.
2. Place the MATCHING IMPEDANCE switch in a suitable position for the application.
   N.B. Full deflection of the instrument meter corresponds to the voltage indicated by the switch position.
3. Connect the load to the output terminals marked LOAD.
   N.B. Right-hand terminal is grounded.
4. Turn the pointer on the main frequency dial to the desired frequency, finally adjusting the FREQUENCY INCREMENT if necessary. (For automatic frequency sweep, see under E).
5. Select a suitable output voltage by turning the knob marked OUTPUT VOLTAGE.

C. Operation Using the Built-in Output Attenuator.

Apply the following procedure:—

1. Set-up and calibrate the oscillator as described in A.
2. Set the MATCHING IMPEDANCE switch in the position "Att.".
3. Select the appropriate voltage range by means of the ATTENUATOR.
   N.B. Full deflection of the instrument meter corresponds to the voltage indicated by the switch position (mV or dB re. 1 volt).
4. Connect the load to the screened output socket on the top of the instrument marked ATTENUATOR OUTPUT.
5. Proceed as in B, 4 and 5.

D. Frequency Modulation.

When a frequency modulated output signal is required, the following procedure should be adopted:—

1. Turn the knob marked MODULATION FREQUENCY to the required frequency.
2. Turn the knob marked FREQUENCY DEVIATION to zero.
3. Re-calibrate the Oscillator as described in A.
4. Set the FREQUENCY DEVIATION knob to the required frequency swing (bandwidth).
5. Proceed as described in B items 2 to 5, or C items 2 to 5, dependent on the requirement.

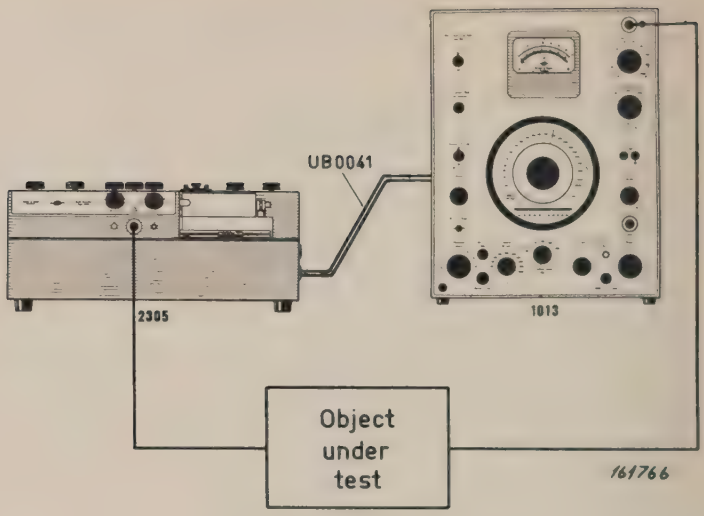


Fig. 3.1. Arrangement for automatic recording of the frequency response of four-terminal networks using Type 1013 + Type 2305.

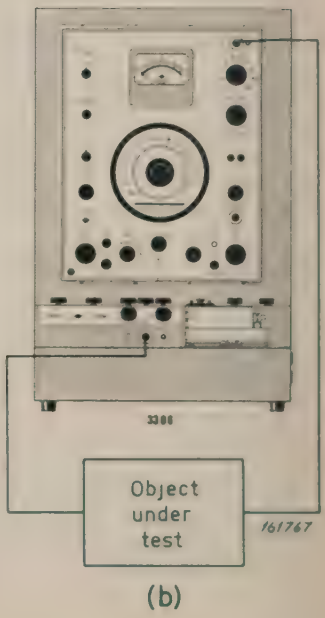


Fig. 3.2. Arrangement for automatic recording of four-terminal networks using Type 3306.

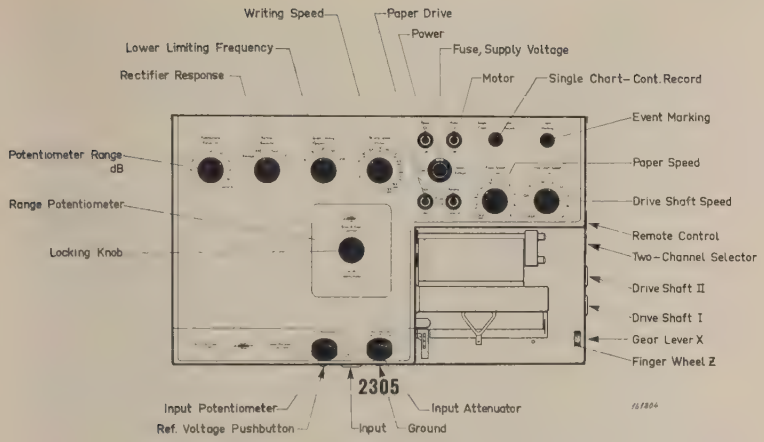


Fig. 3.3. Level Recorder Type 2305. Top view.

E. Automatic Recording.

By combining BFO Type 1013 and Level Recorder Type 2305, or using Automatic Frequency Response Recorder Type 3306, it is possible to automatically record the frequency response of four-terminal networks. When using BFO Type 1013 and Level Recorder 2305, it is necessary to connect the two instruments mechanically by a Flexible Shaft UB 0041 as in Fig. 3.1 and to make the electrical connections also shown. Fig. 3.2 depicts the use of the Automatic Frequency Response Recorder Type 3306 with the required external connections.

For setting-up, calibrating and synchronizing the combination the following procedure should be adopted:—

1. Ensure power supplies are correct and switch power toggles to the "On" position. Set Level Recorder START/STOP switch to "Stop".
2. Calibrate the B.F.O. as described in A.
3. Connect the instruments as shown in Fig. 3.1. This is done by connecting a flexible driving cable (UB 0041) to the upper driving shaft of the Recorder "Drive Shaft I" located at the right-hand side and to the front of the Level Recorder. Taking the other end of the cable, insert and screw in drive on left-hand side of BFO. (Check engagement by switching the Level Recorder START/STOP switch to "Start" and the BFO AUTOMATIC SCANNING to "On" and note if scale rotates).
4. Switching PAPER DRIVE to "Stop" continue with the following procedure referring Fig. 3.3.

5. Load the Level Recorder with the desired recording paper. (Follow instructions in Level Recorder Manual).
6. Select and insert required Range Potentiometer. (N.B. Place POTENTIOMETER RANGE dB switch to "Standby" when altering potentiometers).
7. Switch POTENTIOMETER RANGE dB until figure corresponds to the Range Potentiometer being used, i.e. "10", "25", "50" or "75".
8. By means of the switch RECTIFIER RESPONSE, select RMS or if specially required one of the other three positions Average, Peak, or DC.
9. Turn the LOWER LIMITING FREQUENCY switch to the cut-off value (2, 10, 20, 50 or 200 Hz).
10. Set WRITING SPEED to required position.
(Full explanations of items 8, 9 and 10 can be obtained from the Level Recorder Manual).
11. Place REVERSE/FORWARD switch to "Forward".
12. Select PAPER SPEED to a suitable speed, e.g. 10 mm/sec.
13. Pull Gear-Lever marked "X" to the outer position. (See Fig. 3.3).
The actual paper drive speed now corresponds to the *small numbers* marked around the PAPER SPEED knob.
14. Two types of recording can be made:—
    (a) Single chart recording (automatic recording over a length of 250 mm paper only).
    (b) Continuous recording over any length of paper.

    (a) **Single Chart Recording:**
    Set the PAPER DRIVE toggle switch to "start" commencing the paper to run, which will continue until the built-in automatic stop switch declutches the drive mechanism (less than than one chart length).
    Reset recording paper by finger wheel Z (Fig. 3.3) until the stylus rests on the 10 Hz line.
    A chart of 250 mm length will now run off when the SINGLE CHART — CONTINUOUS RECORDING pushbutton is pressed and released again immediately afterwards. It is possible to stop the recording at any time by setting the PAPER DRIVE toggle switch to "stop").

    (b) **Continuous Recording:**
    The operator should follow the instructions outlined under (a), i.e. SINGLE CHART RECORDING, except that to start the recording it is necessary to press the SINGLE CHART — CONTINUOUS RECORDING push-button and turn it clock-

wise. Recording will now automatically take place until the push-button is released again and the PAPER DRIVE, START-STOP toggle switch is set to "stop".

Note: Whenever the PAPER DRIVE, START-STOP toggle switch is in the "stop" position the paper drive is completely controlled by the SINGLE CHART — CONTINUOUS RECORDING push-button.

15. In order to synchronise the units, stop the paper so that the stylus rests on the 10 Hz line.
16. Adjust the commercing of the reference line on the paper to a suitable level, any necessary fine adjustment being made with the Input Potentiometer.
17. Set tre pointer of the BFO on 10ooo Hz REFERENCE SIGNAL and engage the magnetic clutch by use of the AUTOMATIC SCANNING switch. The units should then be synchronised.
18. Push the 10ooo Hz REF. SIGNAL button. The BFO then generates a signal of 10ooo Hz enabling the operator to select a reference signal which is in the middle of the range. (This makes certain that when taking a recording of frequency characteristics, where the lowest attenuation is around 10ooo Hz, that the deflection of the stylus lies within the scale limits of the paper during the recording).

Continuous Recording with Ten Times Enlarged Paper Speed.

The following method is adopted: Set the "Gear Lever X" (Fig. 3.3) in its inner position (released). The actual paper drive speed then corresponds to the *large numbers* marked around the PAPER SPEED knob. Recording on frequency calibrated paper is not possible in this position.

The start and stop of the recording will in this case be completely controlled by means of the PAPER DRIVE toggle switch.

F. Partial Blocking of Frequency Range.

The initial and/or the final part of the frequency range can be blocked by means of the camdiscs mounted on the spindle of capacitor (Fig. 3.4). The frequency range can be reduced to approximately one octave in any part of the frequency range.

The blocking range is adjusted as follows:

1. Disconnected the instrument from the power supply line.
2. Remove rear plate of apparatus.
3. Loosen knurled lock-nut (Fig. 3.4) sufficiently for the outer and inner cam disc to be moved relative to the one in the middle. Hold back the dial knob.

4. Set the pointer of the main scale to the lowest frequency of the desired frequency range.
5. Turn the inner disc to the right (seen from behind) until the contact is activated by the cam disc.
6. If necessary tighten the lock-out so much that the cam disc is not displaced when the main scale pointer is moved.
7. Set the main scale on the highest frequency within the desired frequency range and turn the outer cam disc to the left until the contact is activated. Be carefull that the inner cam disc does not move.
8. The cam disc in the middle should be rotated so that it does not interfere with the frequency range in use.

Fig. 3.4. Cam disc arrangement.

9. Tighten the lock-nut, still being carefull that the cam discs do not move.
10. Replace the rear plate.
11. Connect the apparatus to the power supply line and set POWER switch to "On".
12. After a few minutes warm up calibrate as described in A. This can be done when the REMOTE CONTROL plug is removed.
13. Replace the REMOTE CONTROL plug and set the main scale pointer to a frequency inside the desired frequency range.
14. Turn OUTPUT LEVEL to a suitable deflection on the meter.

15. When rotating the frequency scale pointer over the entire scale there will be a signal (meter deflection) only inside the desired frequency range.

Note! If there is no blocking of the frequency at all check that the REMOTE CONTROL plug is well home. If the frequency range is not correct start procedure over once again from F. 1.

G. Automatic Regulation of the Output Power.

By means of the compressor circuit it is possible to regulate the output from the oscillator. When a constant output voltage is required, the output voltage from the Oscillator is used as a control voltage. A constant current is obtainable if the voltage drop across a resistor connected in series with the load, is used as the control voltage, and a constant sound pressure is maintainable with the aid of a regulating microphone. The microphone is placed in the sound field from a loudspeaker, driven by the Oscillator. The microphone output voltage is then used as control voltage. It is essential that the frequency characteristic of the microphone and the microphone amplifier is linear.

Proceed as follows:—

1. Calibrate the Oscillator as described under Frequency Calibration, see under A.
2. Set the MATCHING IMPEDANCE switch in the desired position.
3. Connect the load to the LOAD terminals or to the screened output socket on the top of the instrument, see B and C.
4. Feed the control voltage to the COMPRESSOR INPUT terminal. If necessary use an amplifier which has a linear frequency characteristic for the amplification of the control signal. Approximately 3 volts is required for full utilization of the compressor.
5. Set COMPRESSOR VOLTAGE and OUTPUT LEVEL to maximum (fully clockwise).
6. Feed to voltage to be measured to the recording instrument, e.g. the Level Recorder Type 2305.
7. Set the COMPRESSOR SPEED switch in one of the positions: 30, 100, 300 or 1000 dB/sec (as required for measuring stability).
8. Regulate the desired output voltage by turning COMPRESSOR VOLTAGE knob counterclockwise.

Note: When the Beat Frequency Oscillator is used in conjunction with the Level Recorder Type 2305 the writing speed of the Level Recorder should be kept below the regulation speed of the compressor.

It is also possible to obtain different regulation characteristics dependent on the position of the potentiometer marked OUTPUT LEVEL. This can be seen from Fig. 1.2.

H. Remote Control.

In the description of the apparatus several forms of remote control are mentioned. To carry out any of these methods use must be made of the REMOTE CONTROL jack on the front panel, the appropriate connections being made of the pins of the six-pole socket. Fig. 2.6 shows the different pins on the socket.

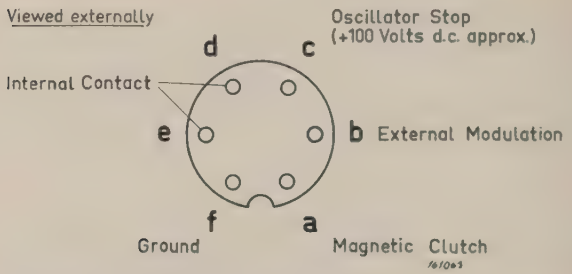


Fig. 3.5. REMOTE CONTROL jack, viewed looking towards front panel.

Remote control of the magnetic clutch can be obtained by setting or breaking a connection between a and f, providing the AUTOMATIC SCANNING switch is at the position "Off".

For external modulation it is necessary to connect the external generator between terminals f and b, having the MODULATION FREQUENCY switch set to any position except "Off".

For remote interruption of the output signal (stopping of the fixed oscillator) the terminal c should be connected to terminal f (ground). This arrangement is used, for instance, when reverberation measurements are carried out automatically by employing the B & K Level Recorder Type 2305. A special switch in the Recorder then connects terminal c to ground when the radiated signal has to be interrupted.

Terminals d and e are in connection with an internal contact used to interrupt the signal output when the frequency scale pointer is outside the scale. This internal contact is also in use when the Partial Blocking arrangement is utilized.

Note: When delivered from the factory, each BFO is supplied with a 6-poled plug containing the necessary connections for the function of the internal contact.

I. Trouble Shooting.

If the BFO is not working properly when switched on, check the following:—

1. That 6-poled plug for REMOTE CONTROL jack is in position.
2. That scale-pointer is not situated in the uncalibrated section of the main dial, i.e. between 200ooo Hz and 200 Hz.
3. That scale-pointer is not on a section chosen for "partial blocking of frequency range".

4. Combined Units

Most B & K instruments can be delivered in three different versions, and the user can therefore, to his individual choice, order just that configuration, which is convenient to his use.

The mechanical design is such that the instrument, which are delivered in lightweight metal cases (Type A) as a standard fitting, can very easily be mounted in any af three ways, i.e.:

Mahogany cabinet (Type B), frame for 19″ standard rack (Type C), or B & K combination mounting unit.

Automatic Frequency Response Recorder Type 3306.

This unit contains a Beat Frequency Oscillator Type 1013 and the Level Recorder. It is designed for automatically measuring frequency response curves etc. in the frequency range of 200 Hz to 200 kHz. Recordings can be

Fig. 4.1. Automatic Frequency Response Recorder Type 3306

made on preprinted amplitude/frequency calibrated paper:— QP 0123 — 0423 — 1123.

The mechanical connection between the Level Recorder and Oscillator is obtained with a permanent chain drive which may be connected either to DRIVESHAFT 1 or 2, the latter giving the possibility of varying the relative speed between the paper drive and the chain drive for compression and expansion of the recorded curves. Connection of the two driveshaft is further described in the instruction book for the Level Recorder Type 2305.

Automatic Frequency Response Recorder Type 3328.

The Automatic Frequency Response Recorder Type 3328 has been developed to allow continuous recording of the frequency response of electrical, electro-acoustic or electromechanical networks in the range 2 Hz to 200000 Hz.

The B & K combination mounting unit consists of the two Beat Frequency Oscillator Type 1013 and 1017 and the Level Recorder Type 2305.

To allow automatic operation over the full 5 frequency decades 2—200000 Hz, two built-in relays ensure proper cross-over from the use of the one oscillator to the use of the other.

Note. All terminal connections should be made to the Type 1013 oscillator. The only "critical" part of the operation is the adjustment of the output and compressor control potentiometer. The setting of these potentiometers must be made separately on each oscillator and in such a way that the same amount of compression takes place on both sides of the cross-over frequency.

The cross over frequency is adjusted at the factory to be 2000 Hz but can be adjusted to any frequency between 200 and 2000 Hz if desired.

Three push-buttons on the front of the combination unit allow proper selection of operation. When the push button marked "1017" is pressed the output from the 1017 will be available on the output terminals of the Type 1013 oscillator. The compressor of the 1017 is now controlled by the signal applied to the COMPRESSOR INPUT of Type 1013. The BFO Type 1013 is in this case set out of operation by means of the built-in relay circuits. Pushing the button marked "1013" the Type 1013 oscillator is in operation while the 1017 oscillator is disconnected.

If the push-button marked AUTO is pressed the 1017 oscillator is in operation below the cross-over frequency while the 1013 oscillator is in operation above the cross-over frequency.

Two lamps placed beside the push-buttons indicates which instrument is actually in operation.

Finally, it is also possible to operate the two oscillators separately disconnecting the interconnecting cable and inserting the shorting plugs, supplied with the instruments upon delivery.

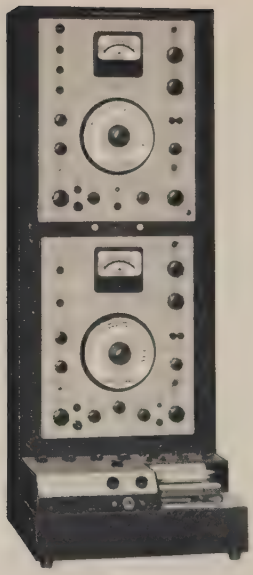


Fig. 4.2. A.F. Response Recorder Type 3328.

The oscillators may then be used, either when mounted in the combination unit, or they can be removed from the unit and operated at a convenient place in the laboratory or workshop.

Use of the Compressor Circuits and Operation.

The voltage applied to the COMPRESSOR INPUT (of Type 1013) should be greater than 3 Volts for proper operation of the compressor circuits. A built-in attenuating network automatically feeds the correct voltage to the two compressor circuits when the two COMPRESSOR VOLTAGE knobs (one on the 1013 and one on the 1017 oscillator) are set to approximately the same value on the scales.

When the compressor circuits of the instruments are used it is recommended to check the proper operation of the circuits during cross-over before commencing the actual measurements. This can be done simply by observing the voltage on the meter of the compressor amplifier. It should be constant when passing the cross-over frequency.

The two oscillators are insulated from the combination unit to avoid ground-loops. It is essential for correct operation that ground loops are also avoided in the external loop when the compressor circuits are utilized. The measuring

object should thus only be grounded at one point, preferably at the oscillator output. In vibration experiments, when the compressor input signal may be the output from an accelerometer the accelerometer should be electrically insulated from the test specimen.

Synchronization.
Synchronization of the two oscillators is made by simply turning the respective frequency dial pointers to the same frequency and set the AUTOMATIC SCANNING to "On". Detailed informations on the operation of the two oscillators as well as the Level Recorder is found in the separate instruction manuals for the three instruments.

Preprinted Paper.
A special preprinted recording paper QP 1141 has been produced for use in conjunction with the Type 3328 Automatic Frequency Response Recorder. The paper width is 100 mm and it is intended for ink writing.

5. Applications

ELECTRONIC MEASUREMENTS

Frequency Response Measurement of Four-Terminal Networks.

The object to be tested, for example a filter, transmission line, transformer, etc. is fed directly from the Beat Frequency Oscillator Type 1013.

Point-by-point measurements can now be taken by means of the Microphone Amplifier Type 2604 or the Voltmeter Type 2409. However, if automatic recording of the frequency response is desired, the Automatic Frequency Response Recorder Type 3306 can be used.

Due to the low output impedance in the 6 ohm position of the MATCHING IMPEDANCE switch, the output voltage of the Oscillator will normally be

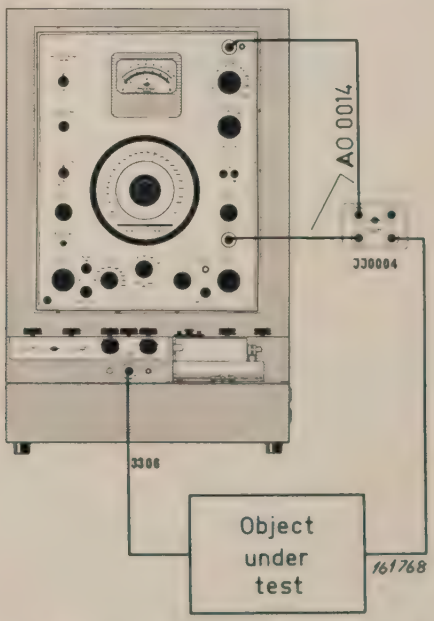


Fig. 5.1. Measuring arrangement for automatic recording of the frequency response of four-terminal networks. The combined BLO and Level Recorder Type 2305, i.e. "Automatic Frequency Response Recorder" Type 3306 is used.

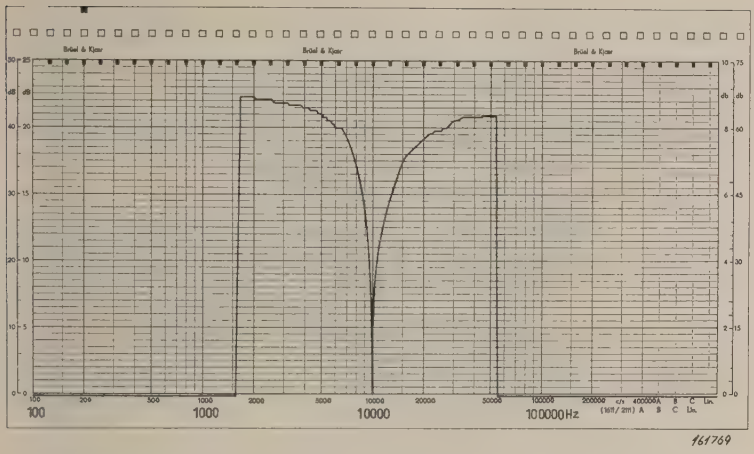


Fig. 5.2. Frequency response of a filter measured by the set-up in Fig. 5.1.

constant during a recording. Should, however, the generator impedance not be small in comparison with the input impedance of the test object, use should be made of the compressor arrangement. An example showing an AF filter under examination and utilizing the compressor to obtain a constant input voltage is shown diagrammatically in Fig. 4.1. Fig. 4.2 shows the frequency response of a filter measured by this method.

AC Bridge Measurements.

Employing the BFO Type 1013 as signal source and the Electronic Voltmeter Type 2409 as indicating instrument, AC bridge measurements can be carried out.

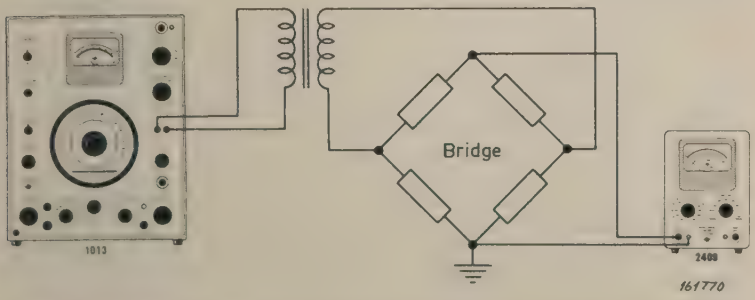


Fig. 5.3. BFO Type 1013 used as voltage source for AC bridge measurements.

However, care should be taken as to which point of the bridge is grounded. Fig. 4.3 shows the measuring arrangement using a screened balancing transformer between the Oscillator and the bridge. This is necessary because the right-hand output terminal of the BFO is grounded. The B & K Balanced Output Transformer TU 0005 can be used in the frequency range 20—35000 Hz.

Automatic Recording of Electrical Impedance.

By using the Automatic Frequency Response Recorder Type 3306 it is possible to record automatically the numerical value of the impedance or the admittance of a two-terminal network as a function of frequency. The impedance is measured by keeping the current through the test object constant, and recording the voltage across the object, while the admittance can be found by keeping the voltage constant and measuring the current.

Fig. 4.4 shows a measuring arrangement suitable for this type of measurements. The current is kept constant by supplying the COMPRESSOR INPUT with the voltage drop across a series resistor.

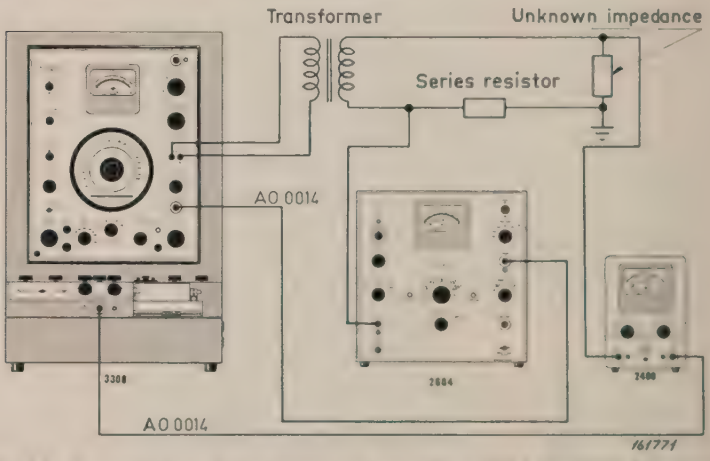


Fig. 5.4. Measuring set-up for automatic recording of the electrical impedance of a two-terminal network.

To be able to separate the ground connections it is necessary to use a screened balancing transformer between the BFO and the object to be measured. Measurement of the admittance can be done in a similar set-up. In this case the connections to the Level Recorder and the COMPRESSOR INPUT have to be interchanged. This method is very convenient for a quick and easy check of the resonance peaks of a transducer. As an example Fig. 5.5 shows the impedance of a piezoelectric transducer.

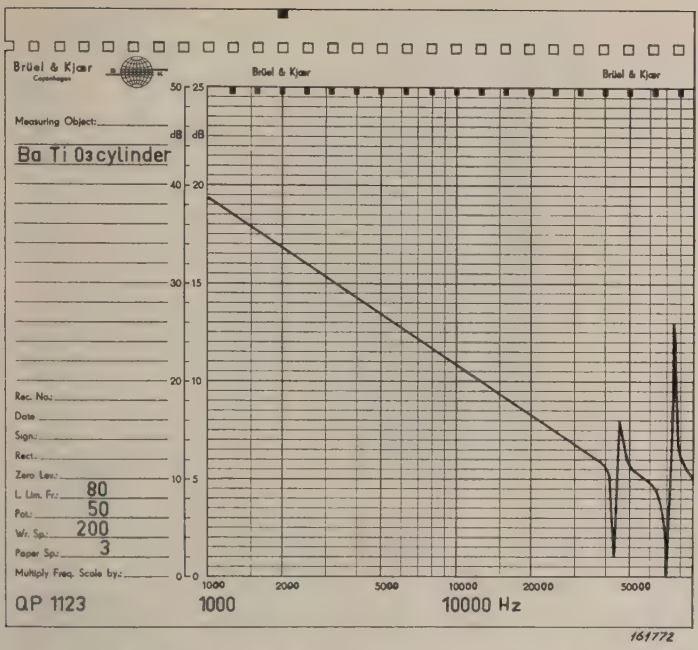


Fig. 5.5. The impedance of a piezo-electric transducer as a function of frequency obtained with the set-up illustrated in Fig. 5.4.

Frequency Range of High Quality Amplifiers.

The Beat Frequency Oscillator Type 1013 which covers the frequency range 200—200000 Hz and the Beat Frequency Oscillator Type 1017 which covers the frequency range 2—2000 Hz will when combined cover the frequency range from 2 Hz to 200000 Hz. This is done in the Automatic in the Automatic Frequency Response Recorder Type 3328, which consists of a BFO Type 1017, a BFO Type 1013 and a Level Recorder Type 2305 mounted in a Rack and with manual as well as automatically switching between the BFO 1013 and 1017. Using the automatically switching and the recording paper QP 1141 the whole frequency range 2—200000 Hz can be recorded automatically and Fig. 5.6 shows the set up for measurements on a high quality amplifier. The operation of the 3328 is described under section 4 «Combined Units». The cross-over frequency in this case was 300 Hz. (As mentioned in section 4 it is from the factory adjusted to be 2000 Hz) and Fig. 5.7 shows the frequency response of the amplifier. When properly adjusted there will be no change in level when the "cross-over" frequency is passed.

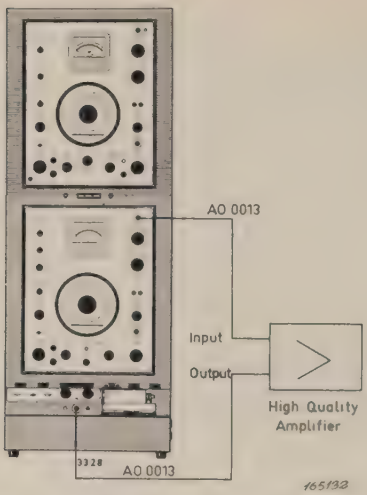


Fig. 5.6. Measuring arrangement for recording frequency response of amplifiers in the range 2 Hz to 200000 Hz.

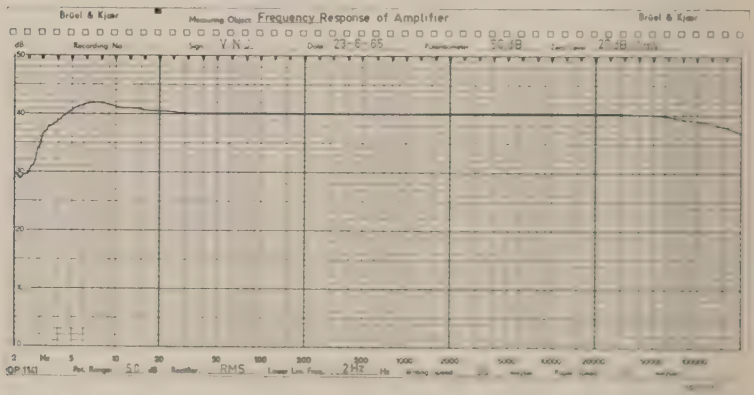


Fig. 5.7. Amplitude vs. frequency characteristic of a Hi-Fi amplifier recorded by the equipment shown in Fig. 5.6.

ACOUSTICAL MEASUREMENTS

Frequency Response of a Loudspeaker (Tweeter).

By connecting the Level Recorder with the B & K Microphone Amplifier Type 2604, the Condenser Microphone Type 4133, a Cathode Follower Type

2615 and the Beat Frequency Oscillator Type 1013 as illustrated in Fig. 5.8 a measuring arrangement for the automatic recording on frequency calibrated paper of the frequency response of tweeters is gained. To give results

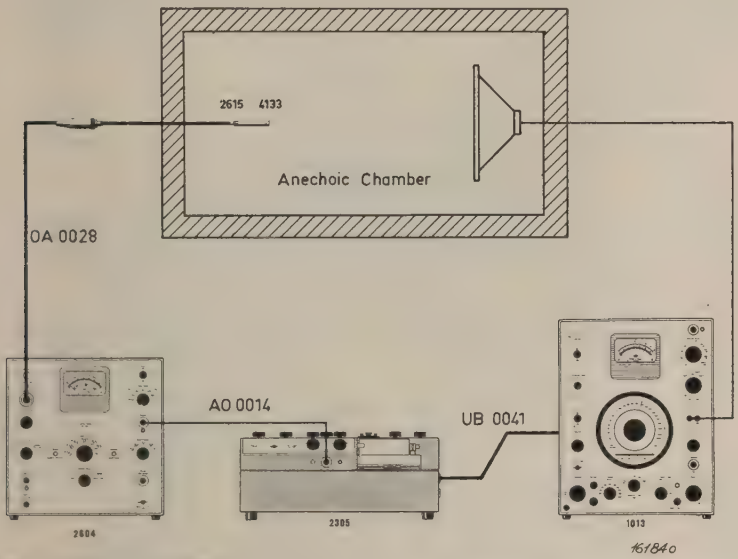


Fig. 5.8. Automatic recording of loudspeaker (tweeter) frequency response.

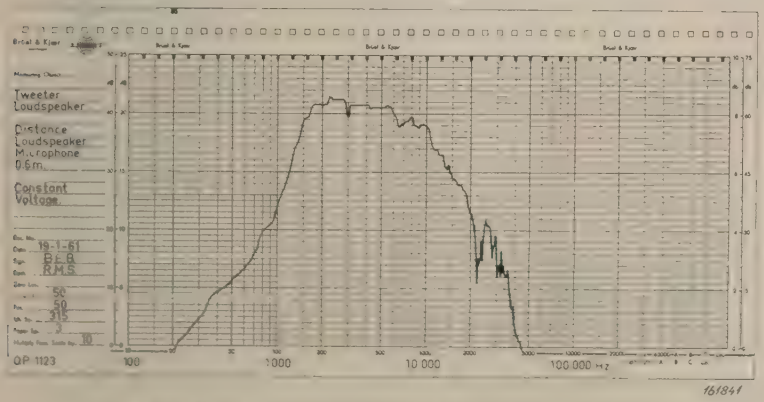


Fig. 5.9. Free field characteristic of a tweeter loudspeaker.

independent of room response the measurement has to be carried out in an anechoic chamber. The complete measuring set-up in Fig. 5.8 covers a straight frequency range of 200—40000 Hz. By substituting the Beat Frequency Oscillator Type 1013 and the Microphone Type 4133 by other B & K types the frequency range can be altered to cover 20 to 20000 Hz. The range of sound pressure level is approximately 20—160 dB with reference 2×10^{-4} μbar.

Fig. 5.9 shows a recording of the free field characteristic obtained in the axis of the loudspeaker.

Directional Characteristics of Loudspeakers.

When the Level Recorder is combined with the Turntable Type 3921 a complete equipment for the automatic measurement of directional characteristics is obtained. For description of the Turntable and its operation, the reader is referred to the instruction book of the Level Recorder Type 2305.

With the measuring arrangement illustrated in Fig. 5.10 the directional characteristic of a tweeter was recorded at various frequencies. In Fig. 5.11 the results are reproduced.

The measuring equipment consists, apart from the Turntable and the Level Recorder, of the B & K Beat Frequency Oscillator (BFO) Type 1013, the

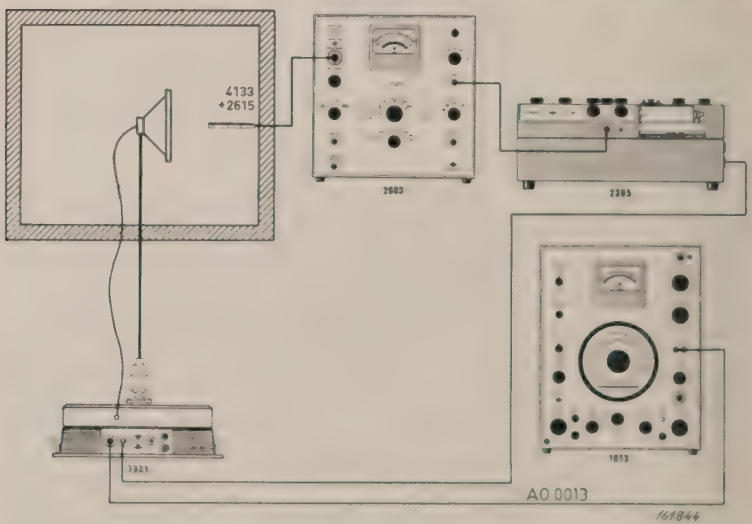


Fig. 5.10. Measuring arrangement for recording directional characteristics of loudspeakers.

Microphone Amplifier Type 2603 and the Condenser Microphone Type 4133. With this combination a frequency range of 200—40000 Hz is covered. When substituting the BFO Type 1013 with for instance the Type 1022 a 20—20000 Hz frequency range wil be obtained. The measurements were carried out in an anechoic chamber to ensure that no reflection would influence the measured results.

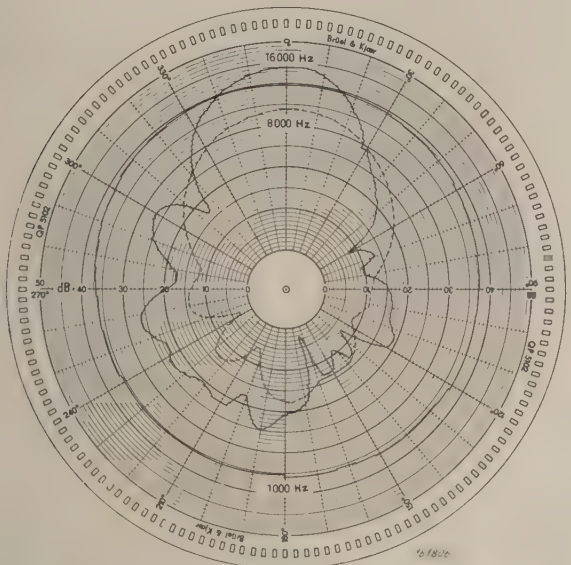


Fig. 5.11. Directional characteristics of loudspeaker measured at the frequencies 1000 Hz, 8000 Hz and 16000 Hz.
The dotted curve is obtained by utilizing the pen lifting arrangement in combination with the Two-Channel Selector.

Recording of the Frequency Response of Sound Projectors.

In Fig. 5.12 is shown the measuring set-up for recording the frequency response of an underwater sound projector. In order to avoid undesired reflections of the sound waves the projector and the hydrophone should be placed in an approximately free field (the sea, a lake or an anechoic tank).

The projector is fed from the BFO of Type 3306 and the driving voltage is kept constant by connecting the Oscillator output to the terminals marked COMPRESSOR INPUT. The sound pressure level at some distance away from the projector is measured with a standard hydrophone which must have a flat frequency response in the required range. The electrical output signal from the hydrophone is then fed to the Level Recorder via a suitable

amplifier. By using preprinted frequency calibrated recording paper the frequency response of the projector can now be recorded automatically. It should be noted that the influence of possible standing waves may be minimised by using the internal frequency modulation of the BFO.

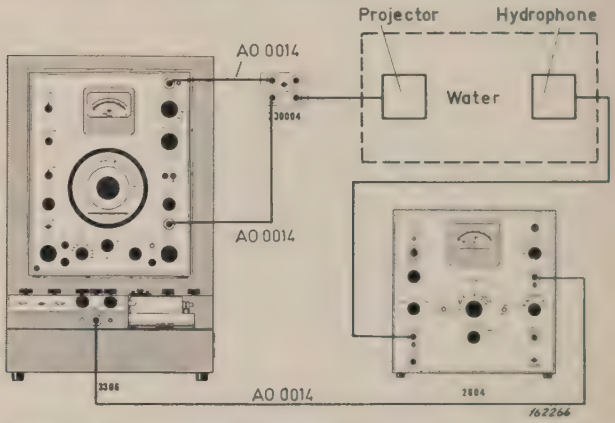


Fig. 5.12. Set-up to automatically record the frequency response of a projector. Use is here made of the combined BFO and Level Recorder Type 2305, i.e. "Automatic Frequency Response Recorder Type 3306.

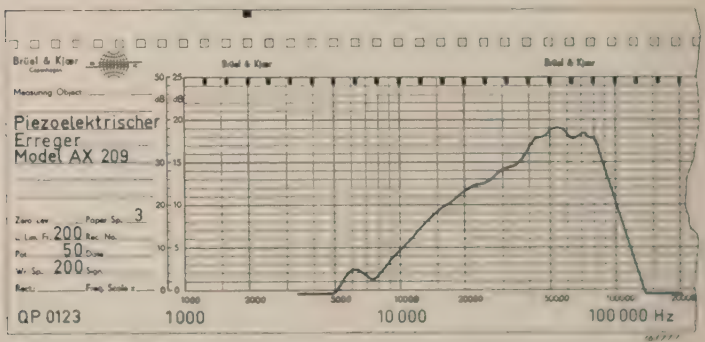


Fig. 5.13. Recording taken with the set-up in Fig. 5.12.

Directional Characteristics of Projectors.

The directional characteristics of an echo sounder projector may be measured by the combination shown in Fig. 5.14.

A projector and a hydrophone are placed in a free field under water, the projector being electro mechanically rotated on the Turntable Type 3921

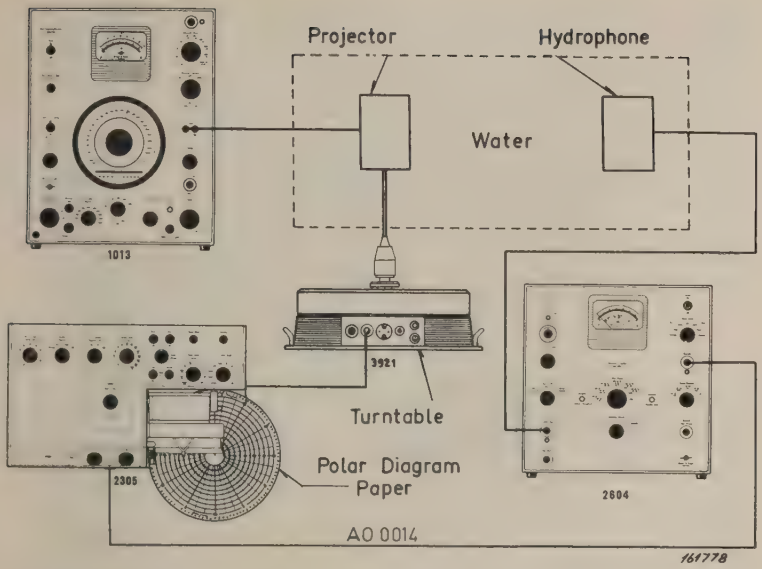


Fig. 5.14. Measuring arrangement for automatic recording of the directional characteristics of projectors.

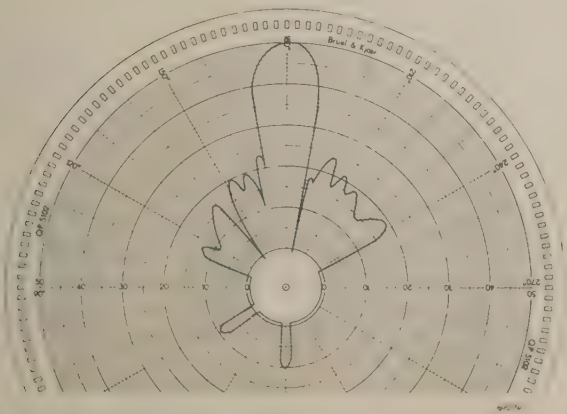


Fig. 5.15. Typical directional characteristic of a projector (Clevite Research Center AX209).

which is controlled from the Level Recorder Type 2305. The signal being applied to the projector is applied from the BFO. The hydrophone is connected to an amplifier, Microphone Amplifier Type 2604, which in turn is connected to the Level Recorder. The Recorder has been loaded with Polar Diagram Paper QP 5102. (See also Level Recorder Manual).

By controlling the Turntable from the Level Recorder it is possible to run it in synchronism with the paper drive motor. As the projector rotates, the sound pressure at the hydrophone will vary in accordance with the directional

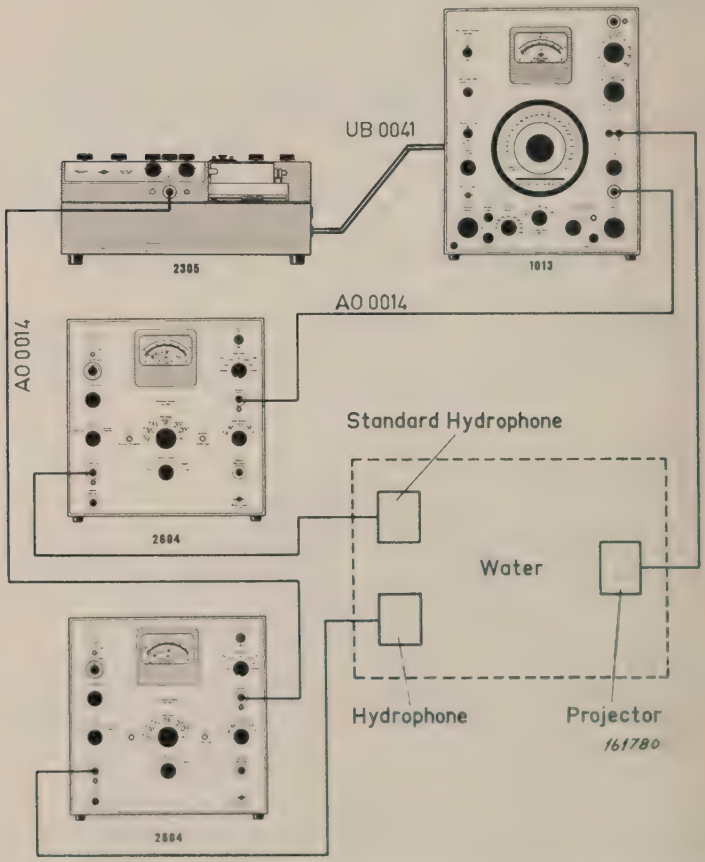


Fig. 5.16. Measuring arrangement for automatic recording of the frequency response of hydrophones.

properties of the projector, and when picked up by a hydrophone it will be transformed into an electrical signal. This signal is then passed via the Amplifier to the Level Recorder and automatically recorded.
In Fig. 5.15 a typical directional characteristic of a piezo-electric projector is shown.

Recording of Frequency Response of Hydrophones.
A projector, a standard hydrophone and the hydrophone to be tested are placed in an appropriate free field under water.
To obtain an automatic recording, the Level Recorder Type 2305 should be used. The mechanical connection between the motor of the Level Recorder and the tuning capacitor of the BFO being effected by means of the Flexible Shaft UB 0041.
In Fig. 5.16 the measuring arrangement is shown. The voltage from a standard hydrophone is fed to the COMPRESSOR INPUT of the BFO thereby making it possible to keep a constant reference sound pressure level at the symmetrically placed hydrophones If the standard hydrophone has a linear free field response in the measured frequency interval, the recording will immediately show the free field response of the unknown hydrophone.
Due to the use of the compressor arrangement, the delay time (i.e. the time needed for the sound to travel the distance from the projector to the hydro-

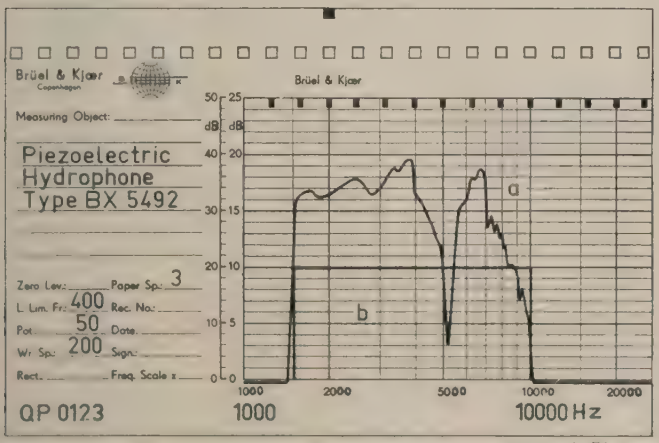


Fig. 5.17. Curve a: Free field response of a hydrophone obtained with the set-up of Fig. 5.16.

Curve b: Recording of the reference sound pressure level on the standard hydrophone.

phones) should be small in comparison with the time constant which determines the compressor speed.
Fig. 5.17 shows a frequency characteristic of a piezo-electric hydrophone measured by the previously mentioned system.

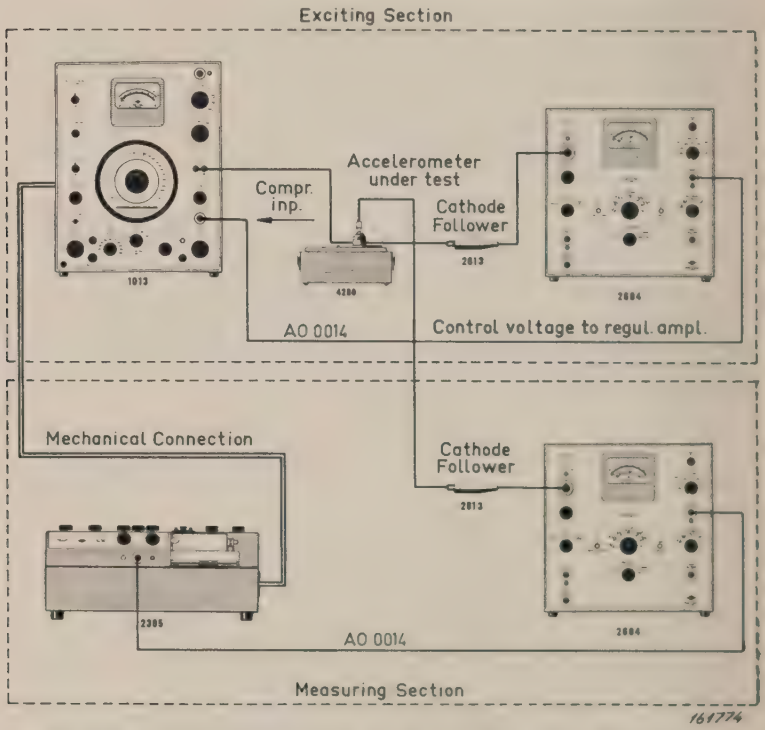


Fig. 5.18. Measuring arrangement for frequency response calibration of accelerometers.

MECHANICAL MEASUREMENTS

Automatic Recording of Accelerometer Frequency Response.
In the production of high quality electromechanical transducers it is a important asset to deliver wit hevery unit an individually recorded amplitude versus frequency characteristic.
The B & K accelerometers, which are duly supplied with individually recorded amplitude vs. frequency curves, are measured on a measuring arrangement equivalent to the one shown in Fig. 5.18. The arrangement con-

sists of an exciting and measuring section. The B & K Calibration Exciter Type 4290 is fed from the Beat Frequency Oscillator Type 1013. To keep a constant acceleration level on the table of the Exciter, the output signal from a built-in accelerometer is applied via one of the B & K Cathode Followers and the Microphone Amplifier Type 2604 to the compressor circuit of the Beat Frequency Oscillator. The output signal from the accelerometer under test is then applied to the measuring section which is comprised of another Cathode Follower and Microphone Amplifier Type 2604, and finally the Level Recorder. To derive automatic scan of the Beat Frequency Oscillator a mechanical connection is made to the Level Recorder.
In Fig. 5.19 is reproduced a typical sensitivity curve of an Accelerometer Type 4334 recorded by this set-up. From the curve is clearly seen the natural frequency of the Accelerometer.

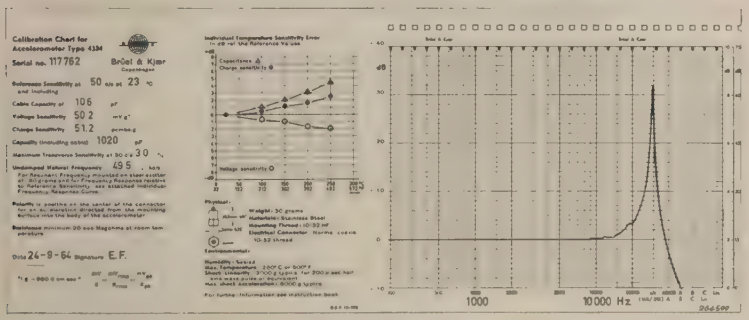

Calibration Chart for
Accelerometer Type 4334
Serial no. 117762
Brüel & Kjær
Copenhagen
Sensitivity at 50 c/s at 23 °C
and including
Cable Capacity of 106 pF
Voltage Sensitivity 50.2 mV/g
Charge Sensitivity 51.2 pcoul/g
Capacity (including cable) 1020 pF
Maximum Transverse Sensitivity at 30 c/s 3.0 %
Undamped Natural Frequency 49.5 kc/s
Polarity
Resistance minimum 20 000 Megohms at room temperature
Date 24-9-64 Signature E.F.
Individual Temperature Sensitivity Error
Physical:
Weight: 30 grams
Material: Stainless Steel
Mounting Thread: 10-32 mf
Electrical Connector: Normal coaxial 10-32 thread
Environmental:
Humidity: Sealed
Max. Temperature: 200°C or 500°F
Shock: Linearity: 3*10³ g/peak for 200 µ sec half sine wave pulse of movement
Max. shock acceleration: 8000 g's/ms
For further information see instruction book
1000
10 000 Hz
266590

Fig. 5.19. Typical accelerometer calibration chart with frequency response curve as obtained with the above type of set-up.

6. Specification

Frequency Range: 200—200000 Hz.

Frequency Scales: Main scale: Logarithmic from 200 Hz to 200 kHz. Tolerance within ± 0.7 degrees of the theoretical logarithmic curve, Vernier driven.
Incremental scale: for exact frequency selection. Range — 500 Hz to + 500 Hz.
Illuminated scales.

Accuracy of Graduation: On main scale: 1 % ± 10 Hz.
Incremental scale: ± 5 Hz.

Outputs:

Matching: Switchable matching impedance for 6, 60, 600 or 6000 ohms. Actual output impedance 10 to 20 % of stated values. Max. power output approximately 2 watts.

Attenuator: Variable in steps of 10 dB from 400 μV to 12.5 V. Continuously variable by potentiometer within each step.
Accuracy, better than ± 0.2 dB within the whole frequency range, ref. position "12000" mV.

Output Voltage Frequency Response:

ATTENUATOR terminal: ± 0.5 dB in frequency range 200 Hz to 200 kHz with reference to 10000 Hz.

LOAD terminals: ± 1 dB in frequency range 200 Hz to 200 kHz with reference to 10000 Hz and 1.5 watt loaded.

Output Voltmeter: Vacuum-tube voltmeter to indicate output voltage. Perfectly guarded against overload. Measuring average value, graduated in RMS for sine-wave signals.

Accuracy: Accuracy (relative to terminal LOAD or input of Output Attenuator).
Scale: 1 % of full deflection.
Attenuator: (Coupled by the switch MATCHING

IMPEDANCE) o.1 dB at 10ooo Hz with reference 10 V.
NB. With MATCHING IMPEDANCE in position "Att." inaccuracy from meter attenuator is zero.

Frequency characteristic: Within ± o.2 dB in the range 200 Hz to 200 kHz. Reference 10ooo Hz.

Signal Noise Ratio: Higher than 70 dB.

Frequency Scanning: Worm gear in oscillator permits variable capacitor to be driven by motor of Level Recorder Type 2305.
Connection by flexible shaft (UB 0041).
Magnetic clutch for set and release of drive.
Provision for clutch remote control.
Complete synchronization with Level Recorder frequency calibrated paper.

Maximum Distortion:

Frequency in Hz	200	2ooo	20ooo	200ooo
ATTENUATOR OUTPUT				
no Load at 5 V, approximately.	o.7 %	o.3 %	o.3 %	1.0 %
LOAD, 1 watt loaded				
6 Ω	1.0 %	o.5 %	o.5 %	1.0 %
6ooo Ω	1.2 %	o.6 %	o.6 %	1.8 %

Automatic Output Regulator: Output voltage automatically regulated when required.
Built-in compressor amplifier allows for a regulating range of at least 45 dB, to within 2 dB in frequency range 200—200ooo Hz.
Required regulation voltage at COMPRESSOR INPUT 3 V (approx.), with COMPRESSOR VOLTAGE potentiometer at maximum, "10".
Input impedance 10 kohms.
Regulation speed variable in steps: 30—100—300 and 1ooo dB/sec.

Frequency Modulation: FREQUENCY DEVIATION continuously variable 0 to ± 2ooo Hz. Modulation frequency of built-in saw-tooth oscillator: 2—4—8—16—32 and 64 Hz variable in steps.
Provision for external modulation.

Stability, Output Voltage: ± 10 % deviation of power supply gives less than ± o.5 dB alteration in output level.

Oscillator Stop: Push-button OSCILLATOR STOP for noiseless switching in reverberation measurements. Remote control available.

Tubes: 5 × 12AT7 (ECC81) — 3 × 6AU6 (EF94) — 6AL5 (EAA91) — EL84 — OA2.

Power Supply: 100—115—127—150—220—240 volts AC. 50—400 Hz. Power consumption approximately 70 watts.

Accessories Included:
2 Plugs JP 0018
1 Flexible Shaft UB 0041
1 power cord
Various fuses and lamps.

Cabinets:
With the mechanical design of all B & K apparatus, it is very easy to interchange the instruments with the various cabinets. The equipments are delivered in metal cases as standard fittings which can be mounted in any desired way i.e. — mahogany cabinet or frame for 19″ standard rack.

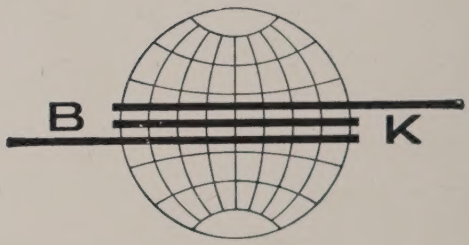
Type 1013 A.
The BFO is in a metal case and is intended for laboratory use.

Type 1013 B.
Similar to Type 1013 A but the instrument and the metal case are housed in a mahogany cabinet with cover. In this cabinet it is easy to transport the instrument.

Type 1013 C.
Similar to Type 1013 A, but it is supplied in a frame ready for mounting the instrument in a 19″ standard rack. The instrument is delivered together with a chain wheel which can be coupled with the chain drive supplied with 2305 C. (The Level Recorder used for 19″ standard rack mounting).

Dimensions:

Ext. dials and knobs	Height	Width	Depth	Weight
Type 1013 A	48 cm 19 inches	38 cm 15 inches	20 cm 8 inches	17.5 kg 38.6 lbs
Type 1013 B	50.5 cm 20 inches	48 cm 19 inches	27.3 cm 11 inches	22 kg 48.5 lbs
Type 1013 C	53.2 cm 21 inches	48.2 cm 19 inches	20.5 cm 8 inches	21.8 kg 48.2 lbs



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